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The development of canned rat bait.

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CONTENTS

CONTENTS (continued)

INTRODUCTION

The purpose of this investigation was to develop a canned bait with red squill as the toxic principle. It was desirable to make at least three kinds of canned baits from any of the following classes of food, namely, meats, fishes, grains, fruits, or vegetables. The resulting baits must be attractive to rats in the field and approach the palatability of fresh baits. The canning process must not destroy the toxicity of the red squill. The ingredients should be of low cost and readily available in order to distribute the baits in volume.

The rat is mankind's greatest enemy in the mammal world. Therefore, any progress that can be made in methods of combatting this pest should be of great value. Space does not permit an enumeration of the many kinds of damage caused by rats. The data can be summarized by stating that the yearly loss attributed to rats is estimated at $189,000,000 in the United States. The rat plays an important part in disseminating at least seven known human diseases and may be a factor in spreading diseases among animals.

Although the permanent control of the rat depends on rat-proofing and the elimination of rat harbors and breeding places, it is not always possible to utilize these methods. Thus, it becomes necessary to destroy rats by means of poison baits, trapping, or fumigation. In most cases, the use of poison baits is the most successful and economical. Success in poisoning depends upon a highly toxic ingredient, attractive baits, and the method of distributing the prepared baits. It is highly essential to expose a

variety of baits to attract and satisfy the most finicky rat. Unfortunately, there is no one rat bait giving universal acceptance so it is necessary to work on the principle of supplying many kinds of food with the hope that at least one of them will prove acceptable to these mammals.

REVIEW OF LITERATURE

A. Red Squill as a Raticide

1. General.

Although the virtues of red squill as a rat poison have been known for a long time, it was not until the beginning of this century that scientific work was started to develop red squill into a commercial product, and more especially the last twenty years. The reason for this late development is probably that the fresh bulb and other types of squill did not give satisfactory results as compared to the more toxic poisons like arsenic, strychnine, and phosphorus. Since the advent of highly toxic forms of red squill, this product has become the chief rat poison of many countries mainly due to its relative harmlessness to other animals and humans. There are few substances which are selective in their action so it makes red squill a highly interesting subject for investigation and a most valuable one for control purposes.

Red Squill is recommended by the governments of the United States (35), Great Britain (10), Germany (24), Denmark (40), and many other countries. Although red squill is used mostly in the powdered form, recent researches indicate that red squill in extract form may find a wider use as it is less likely to be detected by rats.

2. The plant - red squill.

Red squill is a perennial plant belonging to the lily family. The family Liliaceae has 200 genera with 2600 species, red squill

being in the subfamily Lilioideae. The technical names are Urginea maritima (L) Baker or Urginea scilla Steinheil. Steinheil described and named the plant in 1834, while he was living among the Algerian tribe, Ben Urgin, so in honor of them he gave it the generic name Urginea. Scilla, an Italian name, is said to come from the fact that it was originally grown around Scylla, the running mate of Charybdis, a combination which gave so much trouble to Ulysses. Squill grows in the southern part of Italy in the provinces of Rome, Marches, Umbria, Abruzzi, and Calabria. It is also found in the provinces of Agrigento, Caltanissetta, and Messina of Sicily, and in the provinces of Cagliari and Sassari of Sardinia, two islands off the coast of Italy. Squill also grows in the French Colony of Algeria. There is an African species, Urginea burkei, which is inferior to Urginea maritima and has more mucilage than most varieties.

Squill usually grows wild along the seacoast as from Civitavecchia to Minturno, Italy but it may grow in the interior and in the mountains. There is one cultivated planting of 20,000 bulbs started in 1900 with 2,000 additional plantings made in 1929 near the town of Fondi in the Province of Rome. The cultivated variety is said to give a better yield than the wild type and in soft ground the yield is higher than in stony soil. Under cultivation one plant may produce 15 pounds of bulbs in five or six years.

The red squill bulb is pear-shaped, having a diameter from three to six inches and weighing from ten ounces to six pounds. It

is composed of closely overlapping fleshy scales or leaves, similar to an onion. The outer leaves are dry, membranous, and reddish brown; the inner scales vary from light yellowish white to deep mahogany, thick towards the center and thin at the edges; and the central ones or core are usually white. There are two commercial varieties of squill, namely, white and red. Both types are often found growing in the same field. There is no anatomical or chemical difference between white and red squill, the latter having a red color constituent. White squill is non-toxic to rats so further discussion of this type is unnecessary.

3. Collection and sun-drying of red squill.

Red squill to be dried is usually harvested from June to September and particularly during August. The bulbs are carefully gathered so as not to remove the main bulb. Unless the bulbs are shipped fresh, they are dried in the sun. This process consists of discarding the rootlets and exterior scales, slicing, and placing in the sun to dry. They are exposed for about three days, being covered at night after the third day. One thousand grams of the fresh product will produce about 250 grams of dried squill. If rain falls upon the squill when drying, it becomes black and spoils.

4. The use of fresh bulbs as a poison.

Red squill as a rat poison was first used in its fresh bulb form. Danzel (12) states that in the Middle Ages the fresh leaves

hashed and mixed with fat or meat formed a very active paste. Read (32) of the British Ministry of Agriculture gives the following formula:- Chopped red squill one part, bacon drippings one part, and oatmeal or flour three parts. Koller (24) reports that Hubner gives the toxic dose of fresh squill bulbs as 1.5 grams per kilogram of body weight so it is evident that rats must consume considerable amounts of fresh squill for a lethal dose. Schander and Gotze found that rats would eat little of a 20 percent mix with fresh squill and would generally survive.

Squill in its fresh form is not in suitable condition for export in foreign commerce since bulbs do not keep over a long period and transportation costs on a product having about 95 percent water are high. Since most drugs for export are dried at their source successfully, squill should be no exception.

5. Sun-dried squill as a poison.

Sun-dried squill has been used for many years in Europe and practically all European formulas issued during the last twenty years specified powdered red squill. Rodwell (33) in 1858 gave the following formula of an African alchymist:- powdered Scilla maritima, or squill bulb powder, two ounces; and eight ounces of strong-smelling Italian cheese; mix together and serve them out in boluses.

Considerable work was done by Europeans to determine the toxicity of sun-dried squill but they found a great variability

between samples and they were also greatly handicapped because they found that rats varied greatly in their susceptibility. Allowing for rat variability, it was also evident that sun-dried squill had no definite toxicity level as lots varied in killing power. The chief obstacle to using these sun-dried powders was that most of them were weak in toxicity so that rats would need to consume a large amount of squill to kill them but weak squill acts as a repellent in such quantities. There are few sun-dried powders that test less than 1000 mg. per kg.

6. Development of Oven-dried Red Squill.

Munch, Silver, and Horn (27) in 1923 undertook to develop a uniform and highly toxic form of red squill powder. Several lots of fresh bulbs were imported from Italy for laboratory experiments. After working five years, using enumerable methods of drying and feeding rats with the resulting powders, the so-called "oven-dried" method for making powdered squill was perfected. They recommend the removal of the dry outer husks from fresh squill bulbs and then slicing the bulbs transversely into sections one-fourth to one-half inch thick. The slices are then placed in an electric drying oven with a temperature of 80° F., and dried to a constant weight. After drying, the slices are ground so that the powder will pass through a 40-mesh sieve. The powder is packed in hermetically sealed containers. Most of the powdered red squill sold in the United States at the present time is oven-dried.

7. Stabilactivated red squill.

Danzel (12) has recently developed the manufacture of powder, paste, and extract from squill bulbs found in Algeria which is called "stabilactivated red squill." There are two factories in Algeria and one in France making this material. The purpose of this method is to prevent oxidation, hydrogenation and fermentation of the active principle found in squill which Danzel states is in the chromogen or red coloring matter in the bulb. It is accomplished by means of alcoholic and acetic acid vapors to which the bulb is exposed at an optimum and prolonged temperature of 75° C. After this process, it is claimed that the resulting product will keep without deterioration.

8. Extract of red squill.

Many attempts to obtain a highly toxic extract or liquid squill have been made, partly in connection with the determination and isolation of the toxic principle. The chief reason for desiring an extract is palatability since powder contains calcium-oxalate raphides that are somewhat repellent to rats and which rats remember if sublethal doses are consumed. Thus powder does not make a very good repeat or follow-up treatment. It is also conceivable that weak bulbs or powder can be reduced to a highly toxic extract or that less bait would be required if the extract would be more toxic than powder. For example, an extract concentrate has been obtained that was ten times as strong as the original powder.

Experiments by Buck (5) indicate that the best solvent for the toxic principle yet discovered is methyl alcohol. The toxic principle is also soluble in ethyl alcohol, n-propyl, and n-amyl alcohols, also cellosolve (ethylene glycol monoethyl ether). It is insoluble in water, diethyl ether, acetone, ethylene dichloride, chloroform, and 0.8 percent carbonate. Practically 100 percent of the toxic principle in powder has been obtained by extraction with methyl alcohol.

9. The isolation of the toxic principle of red squill.

Many investigators have tried to isolate and identify chemically the toxic principle of squill but without success to date. In many instances it is not clear whether white or red squill was studied. Nearly all work has been done on white squill or the "heart-killing principle." Kopaczewski gives the toxic principle of squill as scillitin, also he isolated scillidiuretin. Buschmann (7) isolated a yellow crystalline glucoside called xanthoscillide.

It is questionable if the toxic principle is a glucoside. Claremont (9) published data on the results of the analyses of 15 red squill powders. Munch interpretes the data that there is a relationship between the toxicity and sugar content since the higher the toxicity the higher the amount of the non-reducing sugar. If it was a glucoside the amount of non-reducing sugar that would be inverted would have decreased instead of increased.

Others have thought that the toxic principle was in the calcium oxalate raphides. Munch, Silver, and Horn (27) fed calcium

oxalate to rats in doses as large as 1000 milligrams per kilo of body weight without producing any effect. Since these raphides are left behind in an extraction process and the extract still produces death in rats, it is evident that the toxic principle is not found in the raphides.

The French school of thought states that the toxic principle is in the chromogen or red coloring matter. Work by Munch (27) and Buck (4) does not substantiate this view.

10. The bioassay of red squill powders.

Methods of chemical assay of red squill do not furnish adequate indications of physiological potency so it is necessary to make a bioassay. Munch, Ward, Mills, Buck, Jarvis (28) make the following recommendations for such a bioassay:- Take normal male rats, not previously used for any other test and weighing between 100 and 200 Gm., starve them for 18 hours, after having been fed on a stock diet for at least one week. Weigh the squill powder to be tested and offer it to the animals in individual dishes. The animals should die within five days if the squill is of proper toxicity for the level or strength of the squill under test. It is desirable to adopt a reference standard red squill powder and make a "characteristic" curve for the laboratory and to feed the standard red squill powder at the same time that any unknown squill is bioassayed. Thus, the bioassay will be accurate and will take into consideration any animal or any other variation occuring at the time.

11. The effect of red squill powder on domestic and other animals.

In the first place, squill powder baits are not readily eaten by human beings and domestic animals, as the unusual flavor or burning sensation of calcium oxalate raphides is easily detected. In the second place, if the squill powder baits are ingested, they usually act as an emetic so that the poison is quickly eliminated from their system. It has been observed that animals in poor physical condition having eaten large quantities of squill bait might succumb to the violent emetic action.

The toxic doses of fresh squill given by Hubner (24) are as follows:- cats 0.2 grams per kilo bodyweight, dogs 1.5 grams, rats 1.5 grams, rabbits 3.5 grams, guinea pigs 6.0 grams, and hens 35.0 grams. Cornerin (24) gives the following toxic doses:- horses 0.2, ruminates 0.5 and pigs 0.25 mg. per kilo.

Read's laboratory in London (unpublished data in files of E. M. Mills) ran a series of tests with squill powder having a lethal dose of 0.8 grams per kilo on rats and gives the following doses:- cattle 0.3 to 1 gram, sheep 0.3 to 0.5, pig below 0.3, fowl above 1.0, rabbit above 0.1, and guinea-pig between 0.4 and 0.5 grams.

To summarize the data on fresh and powdered squill as it effects animals, it is evident that squill is relatively harmless to domestic animals and livestock in the proportion usually used as a rat poison. There are no records of humans being poisoned with red squill. Silver (36) took 15 grains of squill powder without harmful effect and later took 40 grains which caused nausea and vomiting within 15 minutes, but no other effects.

B. Rat Bait Formulas

As there has been no previous work done on canned rat baits, a review of the literature regarding uncanned or fresh baits is the only alternative. The writer has a record of twenty different formulas using some form of squill mixed with food and other ingredients. In addition, there are several authors giving the percentage of squill to use with any attractive rat food. For example, Silver (35) states:- Mix together, dry, one ounce of powdered red squill to one pound of cereal meal, such as, oatmeal, graham flour, corn meal, or bran. Add one pint of sweet milk or water and stir to a mushy consistency.

The formulas issued by various authors have little resemblance to each other and there is no attempt to rank their acceptability to rats except Boulenger (3) who makes the following observations:- Assuming 100 to represent bread, the rat's ideal food, I found oatmeal to stand at 80; tallow at 70; banana at 60; bloater paste at 30; maize, cabbage, dripping, smoked fish and cheese at 20; lard, meat and fresh fish at 10. No statements were found in the literature as to whether or not rats prefer moist baits or dry baits. However, it was observed that most of the recommended formulas were of a dry or pasty nature, rather than a very moist or wet consistency.

To illustrate the wide variation of formulas, a few of them are cited as follows:-

Rodwell (33)	Powdered squill	two ounces
	Strong cheese	eight ounces

Read (32)	Red squill powder	1 part
	Fine oatmeal or rolled oats	2 ½ parts
	Dripping	1 ½ parts
	Red squill powder	1 part
	Fine oatmeal	2 parts
	Castor sugar	2 parts
Hovell (23)	Chopped squill	4 parts
	Cheese, grated	5 parts
	Fat	5 parts
	Meal (oatmeal or flour)	6 parts
Rode	Powdered scilla	5 grams
	Sugar	15 grams
	Flour	150 grams
	Water to make a paste	
Garlough	Ground dried bread	65 pounds
	Ground fresh pork fat	5 pounds
	Ground fresh halibut	20 pounds
	Powdered squill	10 pounds
	Ground dried bread	85 pounds
	Glycerine	5 pounds
	Powdered squill	10 pounds

Few foreign authors recommend a variety of baits given at the same time. Claremont (10) says that each toxic agent should be made up into a variety of different baits, so that if one kind is not taken another kind can be tried. He is the only foreign writer giving this idea.

Silver (35) says that a variety of baits used separately gives the rat a choice of foods and increases the chances of the bait being taken. He lists three classes of food, namely, cereals, meats including fish, and fruits and vegetables. He says that one kind of each

from these classes of food should be used for baiting.

C. Canning Technique

Again, as no previous work has been done with canned rat bait, only general data regarding the process used in the canning of fish and meat can be cited. Cereal or grain baits are not canned. The nearest approach to canned fish bait for rats would be canned mackerel. Bitting (41) recommends that the exhaust process should bring the center of the can up to 130° F. before sealing. The cooking process for number one oval cans is given as 50 minutes at 250° F. Prescott and Proctor (46) says that some fish products require an exhaust as low as 130° F. but others need at least 165° F.

Meat is canned in various forms, such as, boiled beef, corned beef, and beef stew. Hamburg is not canned. As it is intended to can the cheapest kind of meat and a form of meat that can easily be divided into small pieces for rat bait, no canning meat data of other types would be of value.

III. EXPERIMENTAL PART

A. Foods Canned in Laboratory to Find Acceptable Baits.

A great variety of foods were canned on a laboratory scale to find baits of suitable consistency. Various combinations of foods were also included. As dry foods keep relatively well without canning, moist food formulas were used in all experiments. If the resulting baits were dry, the formulas were discarded as the canning process would have been an extra process with no benefit. About 1000 cans were prepared to find desirable baits for further testing. Many other combinations were prepared in addition to those listed in Tables I and II but their listing would make this paper too long for any good purpose.

Discussion of Results

The best formulas discovered after numerous variations in food contents and water proportions were as follows:-

Meat — 6 pounds meat, 8 ounces flour, 6 ounces squill, 40 ounces water

Grain — 2 ounces rolled oats, 2 ounces soaked wheat, 5/16 ounce squill, 3/4 cup water

Fish — 2 pounds canned fish, 4 ounces rolled oats, one pint water, 3 1/4 ounces squill

Although there were other formulas giving a good consistency the canning experiments were run simultaneously with bait acceptability tests so that further laboratory canning of unpalatable baits

Table I. Foods Canned in Laboratory to Find Acceptable Baits

Meat Baits

Hamburg, corn meal, water
Hamburg, rice, water
Hamburg, cornstarch, water
Hamburg, sodium sulphite, starch, water
Horse meat, flour, water
Beef head-meat, starch, Ponceau (color), water
Beef heart-meat, starch, water
Meat scrap, oats, water
Meat scrap, oats, water, anise
Meat scrap, dried blood, oats, water

Fish Baits

Fresh haddock, rice
Fresh haddock, starch
Fresh haddock, water
Fresh mackerel, water
Fresh mackerel, rice, water
Fresh mackerel, starch, water
Manhaden fish meal, oats, water
Manhaden fish meal, cod fish meat, oats, water
Halibut, liver meal, water
Cod fish meal, oats, water, anise

Grain Baits

Corn meal, barley, whole wheat, water
Rolled oats, water
Rolled oats, whole wheat, water
Rolled oats, cracked wheat, water
Rolled oats, barley, water
Rolled oats, whole corn, water
Rolled oats, barley, whole wheat, water
Rolled oats, corn meal, rice, water
Rolled oats, corn meal, water
Rolled oats, rice, water
Rolled oats, corn meal, starch, water
Rolled oats, corn meal, rice starch, water
Whole wheat, rolled oats, sugar, water

Miscellaneous Baits

Bread cubes, water
Bread crumbs, water
Carrots, oats
Rolled oats, whole wheat, hamburg meat
Squash

Table II. Sample Formulae in Laboratory Canned Baits

Canning technique:- Cold mixture packed in tin cans, then heated in boiling water for 15-30 minutes. Cans sealed. Sterilized at 240° F. or 10 lbs. pressure for 30 minutes. Cooled in water.

Formula	Final condition
Raw hamburg, squill 1-16	crumply
Raw hamburg, squill 1-10	crumbly
2 pounds fresh haddock, ½ pint water, squill 1-10	very wet
3 pounds fresh haddock, ¾ pint water, squill 1-16	very wet
3 cans canned fish, squill 1-16, no water	good
2 cans canned fish, 1 pint water, ¼ pound rolled oats, squill 1-16	fair
1½ cups rolled oats, ½ cup corn meal, squill 1-16, water 1 pint	quite dry
1½ cups rolled oats, ½ cup corn meal, squill 1-10, water 2 quarts	very moist
1½ cups rolled oats, ½ cup corn meal, ¼ cup rice, water	very moist
1½ cups rolled oats, ½ cup corn meal, ¼ cup rice, ½ cup water	very dry
2 cups oats, ½ cup meal, ½ cup starch, 1 cup water	medium moist
2 cups oats, ½ cup meal, ¼ cup rice, ¼ cup starch, 1½ cups water	medium moist
1½ cups oats, ¼ cup meal, 1 cup water	too dry
1¼ cup meat scrap, 1½ cup water	too dry
1¼ cup meat scrap, 7/8 cup water	too dry
2/3 cup meat scrap, filled can 2/3 full, add hot water to top	too wet
½ can scrap, hot water to ¾ top of can, no preheat	too moist
¾ can scrap, ½ cup hot water to ½ inch of top of can, no preheat	fair
1½ cups scrap, ¾ cup water	too dry
2/3 cup fish meal, added boiling water, no preheat	too dry
½ cup fish meal, added boiling water, no preheat	good
2/3 cup liver meal, added boiling water, no preheat	wet
½ cup liver meal, added boiling water, no preheat	wet
2/3 cup meat scrap, N.E.R. brand, added boiling water, no preheat	dry
½ cup meat scrap, N.E.R. brand, added boiling water, no preheat	wet
1 cup liver meal, ½ cup boiling water, no preheat	very dry
1 cup liver meal, ¾ cup boiling water, no preheat	too dry
1 cup liver meal, 1 cup boiling water, no preheat	too wet

were not made when these facts were discovered.

The numerous experiments were necessary due to the variation in the exhaust process, final cooking process, and water absorption or free water made available upon the many kinds of foods and combinations used. There seemed to be no way to foretell the final results without actually canning the various formulas.

B. Method of Feeding Rats for Acdeptability Tests and Appraisal of Results.

In order to find acceptable baits to rats, comparative feeding tests were made with white rats. It was assumed that the results obtained with white rats would apply to the common rat in the wild. More variable factors would have added to these experiments if wild rats were used and it is also difficult to trap and maintain wild rats.

The procedure used in most feeding tests was to starve white rats for about 24 hours but with water freely available before exposing baits to them. White rats of about 200 grams were used although it was necessary to use rats of other weights at times and weights of rats used are given in the tables when other than rats of 200 grams were fed. Two or more baits were placed in feeding dishes in the cage with one rat so that the choice of the rat could be recorded. The baits were carefully weighed before placing them in the cages and after two or three hours as indicated in the various tables the baits were removed and reweighed. In cases where the toxicity of the baits was to be tested, regular unpoisoned food was again placed

in the cages after the removal of the poisoned baits in order to prevent the rats from dying of starvation.

The method of appraisal for bait acceptability has not been standardized due to the many factors present in such work. A few of these variable factors might be mentioned. It is very evident that large rats will consume more bait than small rats. Then there is an inherent difference in rats of the same weight as to their choice of foods. This factor is readily seen in most any table of feeding tests, some rats eat more than twice the amount consumed by others, etc. To reduce this difference in taste factor, an average consumption of several rats has been taken. Just how many rats should be used ot obtain a fair average is till debatable. If a feeding test is made between unpoisoned food and poisoned food, it would seem that rats should prefer the unpoisoned food and eat it in lesser quantities. Then there is the factor of repeat feeding, that is, are rats more apt to consume baits which they are receiving daily or are they more apt to eat a new food? No reliable answer can be given to this question.

In order to make the experiments understandable a more or less arbitrary rating will be given to the various baits tested for acceptability. The author has taken into consideration the variable factors involved between the different experiments and will rate the baits as good, fair, and poor. It does not seem possible to bring the results down to a hard and fast

statistical basis for such a rating due to the variable factors as stated above. In a general way the rating given runs as follows:- average rat eating ten grams of unpoisoned food, bait good; around six grams, fair; and around three grams poor. When poisoned bait is fed the rating would be, average rat eating two grams, good; one gram, fair; and less than one gram, poor. Munch (27), and Silver (36) state that rats will eat about one percent of their body weight using red squill baits. Claremont (10) says that caged tame rats eat about one-tenth of their body weight in 24 hours, using unpoisoned food. The following experiments appear to verify these observations.

These statements should be kept in mind when considering the data in tabular form. An endeavor was made to keep the procedure uniform but it was not always possible.

1. All baits were canned unless otherwise stated.
2. All baits contained powdered squill in the ratio of one part squill to sixteen parts of bait by weight excluding added water.
3. All baits were moist except as otherwise stated.
4. The acceptance tests consisted in placing the baits to be tested in feeding dishes in a cage with a single white rat.
5. All rats were starved for 24 hours unless otherwise stated.
6. Twenty grams of each bait were placed in each feeding dish which is sufficient to provide ample food unless otherwise noted.

7. The length of feeding period or time bait was exposed is indicated in each table. A variation of a few hours is of little consequence as most of the rats were starved and would consume whatever amount of food they needed within the first hour.
8. Rats weighed about 200 grams unless otherwise stated.
9. All rats were white rats.

C. Effect of Varying Moisture Content of Unpoisoned Baits upon Acceptability.

At this point, it was deemed advisable to check the acceptability of moist baits over dry ones. If dry baits were better, the canning experiments would have been valueless. The first experiment was made with baits having no squill or poison. (Table III.)

Discussion of Results

Three different water content baits were fed with the result that the very moist baits were much preferred by the rats. Slightly moist baits were consumed about equally to wholly dry ones. Wet oatmeal was rated as good, gummy oatmeal as fair, and dry oatmeal as fair. The result of this experiment was very encouraging. It might be stated that no observations as to whether rats prefer wet or dry baits are found in the literature.

D. Determination of the Relative Acceptability of Rat Bait with Varying Squill Concentrations.

A long series of experiments with different squill content to determine their relative acceptability or best point of palatabil-

Table III. Effect of Varying Moisture Content

of Unpoisoned Baits upon Acceptability

Canned Rolled Oats - No Squill

Rat number		Amount eaten in 24 hours		
		Formula 216	Formula 217	Formula 218
		Grams	Grams	Grams
19		6	4.5	3
20		3	2.5	20
21		4	5.5	19
	Totals	13	12.5	42
19		3	3	19.5
20		2.5	6.5	4
21		5	10	19.5
	Totals	10.5	19.5	43
22		6.5	4	15
23		3	6	17.5
24		10	4	11.5
	Totals	19.5	14	44

Formula 216 dry rolled oats

Formula 217 75 grams rolled oats, 50 grams water (gummy)

Formula 218 50 grams rolled oats, 100 grams water (wet)

ity might be run, but it would serve no useful purpose. In order to kill rats, oven-dried powdered squill as supplied must be used in a proportion not less than one part squill to twelve parts of bait by weight excluding added water. As it is interesting to know whether or not the presence of squill slows up acceptance and to more accurately gauge the results of the following acceptability experiments, a test was conducted. Three formulas were prepared, one with no squill, another with squill in the ratio of one to 12, and another with a squill ratio of 1 to 2.5 parts of bait. (Table IV.)

Discussion of Results

It was evident that the rats detected the presence of squill and as the squill content was increased, less bait was consumed. Almost five times as much unpoisoned bait was consumed (32.5 grams eaten or 54 percent) as the bait with a 1-12 ratio of squill (7 grams eaten or 11 percent). About five times as much bait with a 1-12 ratio (2.5 grams eaten or 4 percent). There was less difference in bait consumption between both baits containing squill (7.5 grams eaten of 1-12 ratio compared with 3.5 grams of 1-2.5 ratio). As bread crumbs are not considered as a very attractive bait and as the rats did consume sufficient bait to poison them even in the presence of unpoisoned food (0.8 grams required to kill 165 gram rat), this experiment showed that squill is a fairly good raticide. Even with a high concentration of a 1-2.5 ratio, some bait was consumed.

Table IV. Determination of the Relative Acceptability of Rat Bait with Varying Squill Concentrations

Rat number	Rat weight	Amount eaten in five hours	
		Formula 201	Formula 202
		Grams	Grams
1	180	5.5	1
2	165	7	4.5
3	267	20	1.5
Totals	612	32.5	7
		Formula 201	Formula 204
		Grams	Grams
7	186	3	0.5
8	190	4	1.5
9	320	4	0.5
Totals	696	11	2.5
		Formula 202	Formula 204
		Grams	Grams
13	170	2.5	1
14	98	1.5	2
15	95	3.5	0.5
Totals	363	7.5	3.5

Summary

Formula	Per cent consumed
201	54
202	11
201	18
204	4
202	12.5
204	6

Formula 201 150 grams bread crumbs, 500 grams water, no squill
Formula 202 150 grams bread crumbs, 530 grams water, 12 grams squill
Formula 204 150 grams bread crumbs, 550 grams water, 60 grams squill
Note: Two feed dishes were placed in a cage with each rat, each containing 20 grams of bait of the formula indicated.

E. Rat Bait Feeding Tests with Baits Containing Oils.

As a previous experiment showed that rats preferred moist baits, a series of experiments were run using oils instead of water. It was thought that perhaps oils would step-up the acceptance of baits and might simplify the canning process.

1. Baits with no squill. (Table V.)

Discussion of Results

The experiments clearly showed that food mixed with any oil was much preferred by rats to dry food. The kind of oil did not appear to be of much consequence. The figures gave 191 grams of food with oil consumed as compared with 14 grams of plain food. Thus, food with oil could be rated good, and food without oil as poor.

2. Baits with powdered squill.

In order to check the palatability of baits having oil added, squill was added except that other grains were used as the standard rat food formula would be too expensive to use in canned bait. Some rats were starved, some were not. (Tables VI and VII.)

Discussion of Results

This experiment showed that when squill is added to the oil baits, oil does not increase their acceptance to any marked extent. In all cases, the oil baits were preferred but none of the baits were accepted very readily. Apparently the squill had a deterrent effect which could not be overcome by this type of bait. All oil baits with grain were rated poor.

Table V. Acceptability of Fresh Grain Baits

with Oils but No Squill

Cage number	Amount eaten in 24 hours Formula 1	Formula 2
	Grams	Grams
1	0	18
2	7.5	16.5
3	3	18.5
Totals	10.5	53
	Formula 1	Formula 3
	Grams	Grams
4	0.5	20
5	1	19
6	2	20
Totals	3.5	59
	Formula 1	Formula 4
	Grams	Grams
7	0	27
8	0	27
9	0	25
Totals	0	79

Basic Formula Whole milk powder, ground whole wheat, salt, oil 1-9 by weight.

Formula 1 Grain, no oil
Formula 2 Grain, undeodorized cocoanut oil -Manila grade
Formula 3 Grain, undeodorized cocoanut oil -Cochin grade
Formula 4 Grain, olive oil

Two white rats to a cage, 40 grams of materials in each feeding dish.

Table VI. Acceptability of Fresh Grain Baits with Squill and Oils

Rat number	Amount eaten in 3 hours		
	Formula 1	Formula 2	Formula 3
	Grams	Grams	Grams
1	0.5	0.5	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	1.5	0
6	0	3	2.5
7	0	0	0
8	1	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	1.5	0.5
13	0	0	0.5
14	0	1	0
15	0	0	1
16	0	0	3
17	0	0	2
18	0	0	0.5
Totals	1.5	7.5	10

Formula 1 200 grams oatmeal, 106 grams corn meal, 34 grams squill

Formula 2 168 grams rolled oats, 84 grams corn meal, 12 grams petrolatum oil, 6 grams glycerine, 30 grams squill

Formula 3 200 grams oatmeal, 100 grams corn meal, 24 grams cocoanut oil, 36 grams squill

Non-starved rats weighing 175-200 grams were fed 15 grams each.

Table VII. Acceptability of Fresh Grain Baits

with Squill and Oils

Rat number	Amount eaten in 12 hours		
	Formula 1	Formula 2	Formula 3
	Grams	Grams	Grams
1	0	2.5	0
2	0	0.5	2
3	0	1.5	0
4	0	3.5	0
5	0.5	2	0.5
6	2	1.5	0.5
7	0	0	0
8	0	3	0.5
9	0.5	1	1
10	0.5	0	0
11	0	0.5	1
12	1	1	1
13	0.5	2	1
14	0.5	4	0
15	0	4.5	0
16	0.5	0	1
17	0	1	0
18	0.5	1.5	0.5
Totals	6.5	30	9

Formula 1 Oats, corn meal, no oil

Formula 2 Oats, corn meal, petrolatum oil and glycerine

Formula 3 Oats, corn meal, cocoanut oil

Rats, well starved, were fed 15 grams each.

F. Comparative Acceptability Tests of Various Baits.

Most of the comparative acceptability tests were made between kinds of food in an individual class of food, such as, grains, meats, and fish. After these tests had been made, the comparative rating between the various baits can be given. The formulas used were the best appearing ones from consistency and other points of view from the mass of ones previously canned as outlined in Tables I and II. The data obtained is found in Tables VIII to XVII.

Discussion of Results

Table VIII. There was no appreciable difference between bread crumbs and rolled oats. Both baits were rated as good. Claremont (10) remarks that fresh breadcrumbs also form an attractive bait for rats and mice but on a large scale are rather troublesome to prepare.

Table IX. Wheat and oats were compared with representative fresh vegetables, such as, fresh carrots and squash. Also whole wheat was compared with cracked wheat in the same experiment. Very little of either the carrot or squash was eaten so the experiment was really a comparison between whole wheat and cracked wheat. Whole wheat was favored over cracked wheat. Carrots and squash were rated as poor with either kind of wheat well taken and rated as good.

Table X. Horse meat was compared with beef meat or hamburg with the result that horse meat was slightly better accepted, both rated good. It has been stated by some authorities (not published) that meat with no fat is preferred by rats. As horse meat has

Table VIII. Comparative Acceptability Test of Rat Bait

Bread Crumbs and Rolled Oats

Rat number	Rat weight		Amount eaten in 8 hours
			Formula 204
			Grams
16	171		2.5
17	196		1.5
18	273		5
	640	Total	9
			Formula 208
			Grams
16	171		0.5
17	196		4.5
18	273		5
	640	Total	10

Formula 204 — 150 grams bread crumbs, 60 grams squill, 550 grams water

Formula 208 — 150 grams rolled, 60 grams squill, 720 grams water

Table IX. Comparative Acceptability Test of Rat Bait

Wheat and Vegetables

Rat number	Amount eaten in 2.5 hours			
	Formula 1	Formula 14	Formula 22	Formula 40
	Grams	Grams	Grams	Grams
21	1	0.75	0.5	3
22	1.5	0	1.25	4
23	5.5	1	0.75	2
24	8	0.5	1	1
25	5	1	1	7
Totals	21	3.25	4.5	17

Formula 1 Whole wheat, rolled oats, squill

Formula 14 Fresh carrots (boiled 1 hour), squill

Formula 22 Canned squash, squill

Formula 40 Cracked wheat, rolled oats, squill

Table X. Comparative Acceptability Test of Rat Bait

Horse Meat and Hamburg

Rat number	Amount eaten in 2.5 hours	
	Formula 32	Formula 35
	Grams	Grams
1	2.5	7
2	3	4.5
3	3	4.5
4	6	4.5
5	8	5
6	12	0.5
7	12.5	6
8	5	7
9	4.5	4.5
10	3	7.5
Totals	68.5	53

Formula 32 Horse meat, starch

Formula 35 Hamburg (sodium sulphite 1%), starch

little fat or gristle, this observation seems to be correct.

Table XI. Canned hamburg was compared with fresh hamburg with the result that the fresh hamburg was much better taken than the canned product. This was to be expected. However, there was sufficient hamburg consumed, even with a choice, to warrant the use of canned hamburg.

Table XII. As meat proved to be very acceptable to rats, further tests were made between various kinds of meats. Hamburg, horse meat, head meat, and heart meat was taken in this order and all meats were rated good except heart meat which was very poorly taken.

Table XIII. As meat scrap is a cheap form of meat, water was added to this product and the mixture canned. Comparing canned meat scrap with canned fresh hamburg, the meat scrap was not well eaten, so the meat scrap was rated poor. Of course, it is not known just why meat scrap is unpalatable to rats.

Table XIV. Again fish meal is a more convenient form of fish to use than fresh fish, so a comparative test was run between these types of fish. The canned whiting fish was preferred to the fish meal but only fairly well taken, the fish meal being scarcely taken. This result was the expected one as dehydrated foods are usually not as palatable as canned or fresh ones even with humans.

Table XV. Since fish meal was so available and convenient to use, the experiment was repeated except that the fish meal was diluted with oats. The results showed that the fish meal-oats

Table XI. Comparative Acceptability Test of Rat Bait

Canned Hamburg and Fresh Hamburg

Rat number	Amount eaten in 4 hours	
	Formula 35	Formula 36
	Grams	Grams
11	3	8
12	5.5	7.5
13	4.5	7.5
14	3	13.5
15	3	14.5
16	7	0
17	8	0.5
18	6.5	4
19	0	13
20	7	3
Totals	47.5	71.5

Formula 35 Hamburg (sodium sulphite 1%), starch

Formula 36 Fresh hamburg

Table XII. Comparative Acceptability Test of Rat Bait Meats

Rat number	Amount eaten in 3 hours			
	Formula 32	Formula 33	Formula 34	Formula 35
	Grams	Grams	Grams	Grams
1	3	1.75	0	4.5
2	1	1.5	0	4.5
3	7.5	1.25	1.25	4
4	6	2.5	0.75	2.5
5	0	2.5	1	2.5
6	3.5	2.5	2	2
7	0	2	1	2.5
8	4.5	6.5	0.75	3
9	0	1.5	2	1.5
10	0.5	1.5	0	6.25
Totals	26	23.5	8.75	34.25

Formula 32 Horse meat, starch
Formula 33 Head meat from beef cattle, starch
Formula 34 Heart meat from beef cattle, starch
Formula 35 Hamburg (sodium sulphite 1%), starch

Table XIII. Comparative Acceptability Test of Rat Bait Hamburg and Meat Scrap

Rat number	Amount eaten in 3 hours	
	Formula 35	Formula 38
	Grams	Grams
1	7	1
2	5	4
3	10	4
4	6	0
5	4	0.5
6	6	1
7	7	0.5
8	9	3.5
9	4	1.5
10	8	2
Totals	66	18

Formula 35 Hamburg with 1% sodium sulphite, starch

Formula 38 Meat scrap (Hinckley Rendering Co.), equal parts rolled oats

Table XIV. Comparative Acceptability of Rat Baits

Canned Fish

Rat number (Av.wt. 175 gms.)	Amount eaten in 2.5 hours	
	Formula 3	Formula 4
	Grams	Grams
11	5.5	2.5
12	4.5	0
13	4.5	1
14	6	0
15	4	0.5
16	1.5	1
17	4	1
18	6	0.5
19	4	7
20	4	3
Totals	44	16.5

Formula 3 Ground whiting fish

Formula 4 Haddock fish meal

Table XV. Comparative Acceptability Test of Rat Bait

Cod Fish and Fish Meal

Rat number	Amount eaten in 3 hours	
	Formula 2	Formula 12
	Grams	Grams
11	0.5	4.5
12	2.25	2.5
13	2.25	1.75
14	2	3.5
15	3.25	0.5
16	0.25	4.25
17	1	10
18	4	3.75
19	2	10
20	0	6
Totals	17.25	46.75

Formula 2 Cod Fish

Formula 12 Fish meal (Dehydrating Process Co.) equal parts rolled oats

combination was preferred to canned fresh fish. However, this experiment did not show whether the rats ate the fish meal-oats because oats were attractive or because the fish meal was less concentrated. As a straight fish bait was preferable, no further work was done with fish meal as experiment XIV showed the rat's preference for fresh fish.

Table XVI. Three kinds of lures were added to grain baits in the hope that the lures would increase the acceptability of the baits. Several formulas by English authors have included lures so it was thought worthwhile to try them. The results of the experiment showed that the lures in the quantity used acted more as a repellent than a lure as very little of the lure baits was touched. This result agrees with Hovell (23) who says that it has been customary for many years to add essential oils to bait for rats whether poisoned or unpoisoned, with the object of making them more attractive. Then he says that recent experiments seem to show that baits are taken more readily which have not been flavored than those which have been treated.

Table XVII. As experiment XVI showed that the essential oils acted as a repellent, the quantity was reduced to about the smallest amount it is possible to use. The results showed that caroway and rhodium were still distasteful to rats but that anise was slightly repellent. Thus, lures or essential oils did not seem to have any great value in increasing the acceptability of baits.

Table XVI. Comparative Acceptability Test of Rat Bait

Grain with Lures Added

Rat number	Amount eaten in 3 hours			
	Formula 1	Formula 23	Formula 24	Formula 25
	Grams	Grams	Grams	Grams
21	5.75	0.25	0.25	0.25
22	9	0	1	0.25
23	7	0	1	2.25
24	2.75	0.5	0	0
25	0.5	0.5	3	2
Totals	25	1.25	5.25	4.75

Formula 1 Whole wheat, oats
Formula 23 Whole wheat, oats, anise 4 drops to a can (0.5 pound)
Formula 24 Whole wheat, oats, rhodium 4 drops
Formula 25 Whole wheat, oats, caraway 4 drops

Table XVII. Comparative Acceptability Test of Rat Bait

Grain with Lures Added

Rat number	Amount eaten in 3 hours			
	Formula 40	Formula 41	Formula 42	Formula 43
	Grams	Grams	Grams	Grams
26	2.5	5	1	0.75
27	6.5	1.25	0.75	1.5
28	2.75	4.75	2.5	5.75
29	7	0	0	0
30	0.5	2.5	0.75	1.5
Totals	19.25	13.5	5	8.5

Formula 40 Cracked wheat, oats
Formula 41 Cracked wheat, oats, anise 1 drop to a can (0.5 pound)
Formula 42 Cracked wheat, oats, caraway 1 drop to a can
Formula 43 Cracked wheat, oats, rhodium 1 drop to a can

Table XVIII. Summary of Acceptability Experiments

Table	Bait formula	Average eaten Grams	Rating
III	Oats, no squill, dry	4.7	poor
	Oats, no squill, gummy	4.7	poor
	Oats, no squill, wet	11.1	good
V	Standard rat food, no squill, dry	1.6	poor
	Standard rat food, no squill, with oil	21.2	good
VI	Oats and meal, dry (not starved)	0.8	poor
	Oats and meal, oil (not starved)	0.4	poor
	Oats and meal, oil (not starved)	0.6	poor
VII	Oats and meal, dry	0.4	poor
	Oats and meal, oil	1.7	fair
	Oats and meal, oil	0.5	poor
VIII	Bread crusts	3	good
	Oats	3.3	good
IX	Whole wheat, oats	6.6	good
	Carrots	0.5	poor
	Squash	0.7	poor
	Cracked wheat, oats	3.4	good
X	Horse meat, starch	6.9	good
	Hamburg, starch	5.3	good
XI	Hamburg, fresh	7.2	good
	Hamburg, starch	4.8	good
XII	Horse meat, starch	2.6	good
	Head meat	2.4	good
	Heart meat	0.9	poor
	Hamburg	3.4	good
XIII	Hamburg	6.6	good
	Meat scrap	1.8	poor
XIV	Whiting fish	4	fair
	Fish meal	1.7	poor
XV	Cod fish	1.7	poor
	Fish meal, oats	4.6	good
XVI	Whole wheat, oats	5	good
	Whole wheat, oats, anise 4 drops	0.2	poor
	Whole wheat, oats, rhodium 4 drops	1	poor
	Whole wheat, oats, caraway 4 drops	0.9	poor
XVII	Cracked wheat, oats	3.9	good
	Cracked wheat, oats, anise 1 drop	2.7	good
	Cracked wheat, oats, caraway 1 drop	1	poor
	Cracked wheat, oats, rhodium 1 drop	1.7	poor
IV	Bread crumbs, no squill	7.2	fair
	Bread crumbs, squill 1-12	2.4	good
	Bread crumbs, squill 1-2.5	1	poor

Table XIX. Summary of the Better Baits

from Acceptability Experiments

Baits with No Squill

Table	Bait formula	Average eaten
		Grams
V	Standard rat food with oil	21.2
III	Oats and water (very wet)	11.1
IV	Bread crumbs	7.2

Baits with Squill

Fish

XIV	Whiting fish	4
XV	Fish meal and oats	4.6

Grain

IX	Whole wheat and oats	6.6
XVI	Whole wheat and oats	5
XVII	Cracked wheat and oats	3.9
VIII	Oats	3
VIII	Bread crusts	3

Meat

XI	Fresh hamburg	7.2
X	Horse meat, starch	6.9
XIII	Hamburg	6.6

G. Summary of Acceptability Experiments.

A summary of the various bait formulas used with the results obtained is given in Table XVIII to see them as a whole. As it is not possible to compare one table with another due to the many variable factors, a summary of the better accepted baits is listed in Table XIX. The listings were made from general observation, keeping in mind the variable factors as much as possible. Thus, the poorer accepted baits were discarded.

Discussion of Results

Whiting fish and fish meal with oats were two of the best fish baits. Although fish meal is easily stored and handled, it is rather expensive. As laboratory experiments showed that the addition of oats to a fish base made a good product, it was decided to use fresh fish and oats for large scale production.

The various experiments showed the best acceptance of soaked whole wheat and oats for a grain. This fact was very clearly shown.

The experiments showed that fresh horse meat or fresh hamburg was best accepted with no great difference between the two. As horse meat could be purchased at less cost than hamburg, horse meat was considered the best bait to use for factory production.

No experiments were made to compare the palatability between the three or four classes of food except that in Table IX which showed vegetables very much inferior to grain. As the best baits from each of the three classes of food gave somewhat comparative or

effective results, it was decided to can three kinds of bait. If one of the three kinds of bait had been markedly poor, further work would have been done in an endeavor to increase its acceptability.

At a later date O'Connor (29) found that meat was the rat's first choice, fish second, and grains third.

H. Effect of Canning on the Toxicity of Red Squill Powder.

No precise experiments were conducted to determine if there was any large loss in the toxicity of squill because of the canning process. From observations throughout the various acceptability tests it was seen that the canned baits killed rats as well as fresh bait so the data was not recorded. These experiments were made before very much was known concerning the variation in squill powders and methods had been devised to accurately bioassay lots of squill powder. Munch (27) had found that the lethal principle was not destroyed in preparing squill biscuits at temperatures around 100° C. One would not expect the canning process to injure the toxicity of squill, if this were true.

Several years later, O'Connor (29) ran some experiments to determine whether or not toxicity was constant and he found that cooking baits with squill for two hours at a temperature of 242° F. had no perceptible effect.

I. Factory Production of Canned Bait.

1. Location of Factory.

An extensive search was made along the New England coast to rent a suitable factory to prepare canned rat baits. It was desira-

able to find a factory near a source of fresh or frozen fish in order to obtain this product at low cost and without the need for storage and refrigeration. Meat and grain could be transported from a distance without serious deterioration. At last a small factory was located at Barnstable, Mass. whose owner had canned fish and clams during the World War. This factory was adjacent to a frozen fish plant and also fresh fish was available nearby. Meat was purchased at Boston, Mass. and shipped by truck daily. Grain was bought through a local dealer.

2. Experiments with Dehydrating Fish.

As the supply of fresh fish was unreliable, most of the canned bait was made with frozen fish. The cheapest species of fish available was frozen whiting at about one cent a pound. Whiting is frozen in pans by spraying water upon the fish at freezing temperatures. Each pan of fish finally weighs around 25 pounds. As considerable water is added to the fish during the freezing process, it is necessary to remove this water and also to reduce the water content in the fish in order to make a suitable bait. It was also desirable to heat the frozen fish to soften their bones to permit grinding in a regular Enterprise chopper.

Experiments were conducted to determine the correct time and pressure to dehydrate fresh or frozen fish in retorts by steam. Thus, pans of fish were placed in small retorts and steam applied according to the data furnished on Table XX.

Table XX. Experiments in Dehydrating Fish

Kind of fish	Weight frozen	Process given	Weight after dehydration	% loss	Weight after 15 minutes additional process	% total loss
Whiting	800	15 pounds 30 minutes	576	18		
Whiting	20	5 pounds 15 minutes	17	15	16	20
Whiting	28	10 pounds 15 minutes	22	21		
Whiting	125	15 pounds 15 minutes	80	36		
Whiting	250	12 pounds 30 minutes	152	39		
Whiting	1000	10 pounds 30 minutes	680	32		
Whiting	1000	5 pounds 30 minutes	874	13		
Cod	100	15 pounds 45 minutes	71	29		
Mackerel	20	5 pounds 15 minutes	17½	12½	16½	17½
	Weight fresh					
Whiting	50	10 pounds 15 minutes	39½	21 (In top basket of large retort)		
Whiting	50	10 pounds 15 minutes	39	22 (In bottom basket of large retort)		

5 pounds steam pressure equals 226.9°F
10 pounds steam pressure equals 238.8°F
12 pounds steam pressure equals 243.6°F
15 pounds steam pressure equals 249.1°F

Discussion of Results

Three kinds of frozen fish were used in the tests but the data shows that there was little difference in the final loss of water between the various kinds.

It was observed that the longer the process or higher the steam pressure the more water was lost although there was a considerable variation in results. The water loss varied from 12½ percent loss for a short, low pressure to 39 percent for a longer process. The lack of uniformity in results was probably due to the variability in the water content during the freezing process and the amount of fish in the retort. In the latter case, it required a longer time to heat a large mass than a small one. It was concluded from the experiments that a process at 15 pounds pressure for 30 minutes would produce about a 25 percent loss of water, the desirable figure.

3. Experiments in Exhausting Canned Rat Baits.

In canning baits, the first step after the bait is prepared for filling into cans is to determine the necessary method to exhaust the filled cans. The authors of the various canning manuals recommend at least a temperature of 160° F. in the center of the can before the covers are sealed and the cans processed. As the factory did not possess a hot water exhaust box, other methods were used. The second method available to canners is called the "steam retort or box method." The third method is to heat the material to be canned in a steam-jacketted kettle and then fill

the hot ingredients into the cans, quickly sealing them. (Table XXI.)

Discussion of Results

It required about 10 minutes to heat the contents of the cans of oats and fish in a water bath of 180° F. and 15 minutes for meat as heat penetration is slower in this denser material. Under method 3, it required about one hour to heat about 50 pounds of meat placed in a steam-jacketted kettle to the temperature of 165° F. Not only was this long period of time a disadvantage but the meat kept sticking to the sides of the kettle. Method 3 was discarded.

The most promising method for factory use was the retort method using steam. Although detailed experiments were run under this method of procedure, the data has been mislaid. However, some recordings were found. When placing cans of wet oats in retorts under any steam pressure, it was found that the ingredients would quickly expand and spill over the cans. It was discovered that the oats bait could be heated to a sufficient temperature for canning by placing under no steam pressure but allowing the steam to flow slowly through the retort. It took about 15 minutes to heat the oats to 145° F. by this method. The fish and oats bait could be easily heated to around 160° F. in about 10 minutes at 10 pounds pressure, meat requiring a slightly longer time than fish. Further data on exhausting time will be given later in this paper.

Table XXI. Experiments in Exhausting Canned Rat Baits

Method 1. Hot water exhaust on laboratory scale. Bait cold at start.

Oats Bait

Temperature of bait to start	75° F.
Cans placed in water	180° F.

End of time	Temperature of bait
4 minutes	100°F.
5 minutes	115
6 minutes	130
7 minutes	138
10 minutes	160

Fish Bait

End of time	Temperature of bait
9 minutes	140
10 minutes	160

Meat Bait

End of time	Temperature of bait
5 minutes	110
13 minutes	140
15 minutes	160

Can size 3 7/16" x 2 1/4"

Method 2. Retort method with steam

Bait	Process time	Temperature, center of can of bait
Fish	5 pounds 5 minutes	150-162° F.
Fish	12 pounds 20 minutes	170
Meat	12 pounds 20 minutes	210
Meat	10 pounds 20 minutes	198
Oats	12 pounds 20 minutes	boiled over
Oats	no pressure 15 minutes	145

5 pounds steam pressure equals 226.9° F.
10 pounds steam pressure equals 238.8° F.
12 pounds steam pressure equals 243.0° F.

Method 3. Meat bait placed in steam-jacketed kettle. Bait stirred.

Time	Temperature of meat
22 minutes	110° F.
30 minutes	126
40 minutes	140
50 minutes	152
60 minutes	165

Moisture content 62-65%

4. Data on the First Experimental Canning of Fish Bait.

After the above mentioned experiment with dehydrating fish and the process of exhausting, it was decided to make up about 2,000 cans of bait. Records were kept on the procedure of three lots and may be seen by consulting Table XXII.

Discussion of Results

Concerning the matter of dehydration, the same variation in water loss appeared as in previous experiments. One lot of 800 pounds of frozen fish yielded 576 pounds or a 18 percent loss and another lot processed under the same conditions yielded 344 pounds from 660 pounds or a 48 percent loss. The only explanation is that this variation was caused by more water in the second lot of frozen fish.

The entire process used during the three lots gave fair results, the chief objection being that the bait did not have the ideal consistency, (It was a little too dry). This defect was remedied by adding a small amount of water to the batch.

The cost of canning this first experimental lot of fish bait cost about ten cents a can. It was about the same cost for the same quantity of fresh bait using fish at a higher price, as freshly mixed baits at various points required the purchase of any available fish either fresh or canned.

5. The Final Process and Formula Used in Canning Fish Bait.

Based on the experience with the first three batches of fish bait, a number of variations were made in succeeding batches until a standard process and formula could be followed to give the

Table XXII. Data on First Experimental Canning

of Fish at Barnstable, Mass.

Lot 1.

1. Dehydrated 100 pounds of frozen cod at 15 pounds pressure (249.1°F) for 45 minutes in retort.
2. Added 4½ pounds powdered squill and 2 quarts water to ground fish. (71 pounds)
3. Exhausted filled cans for 30 minutes with no pressure.
4. Processed sealed cans for 45 minutes at 15 pounds pressure. (249.1°F)
5. Cooled cans. Made 177 - 8 ounce cans.

Lot 2.

1. Dehydrated 800 pounds of frozen whiting at 15 pounds pressure (249.1°F) for 30 minutes.
2. Added 36 pounds powdered squill to 576 pounds ground fish.
3. Exhausted filled cans for 10 minutes at 4 pounds pressure. (224.2°F)
4. Processed sealed cans for 45 minutes at 15 pounds pressure.
5. Cooled cans. Made 1041 - 8 ounce cans.

Lot 3.

1. Dehydrated 660 pounds of frozen whiting at 15 pounds pressure for 30 minutes.
2. Added 21½ pounds powdered squill to 344 pounds of ground fish.
3. Exhausted filled cans for 10 minutes at 4 pounds pressure. (224.2°F)
4. Processed sealed cans for 45 minutes at 15 pounds pressure. (249.1°F)
5. Cooled cans. Made 821 - 8 ounce cans.

Costs for 3 lots.

Whiting	1460 pounds @ 1¢ per pound	$14.60
Cod	100 pounds @ 2¢ per pound	2.00
Squill	62 pounds @ 1.50	93.00
Cans	2039 cans @ 21.20 per thousand	43.23
Shipping cartons for cans 4 @ 29¢		1.16
Estimated express and trucking on material		6.00
Cartons for packing cans 22 boxes @ 8¢		1.76
Coal		1.50
Labor 5 men - 59¼ total hours		38.05
No cost for use of factory		
	Total	$ 201.30

Cost per can 9.8¢

best bait. As the resulting bait in the first few batches was too dry, the dehydrating time and pressure was reduced and water added after the fish had been ground. The exhaust time was increased to five minutes instead of four to make sure that a high temperature of the fish existed before sealing. The final process time was increased to one hour instead of 45 minutes to make certain that no spoilage would develop. The data on a typical batch of fish bait is recorded in Table XXIII.

6. Problems Encountered in Canning Meat Bait.

Tables X, XI, and XII showed that horse meat was as palatable as beef or hamburg when canned, in fact, Table X showed that horse meat was slightly more palatable than beef meat. In addition, it was found that horse meat could be purchased at about one-third the cost of beef meat. Thus, it was decided to can horse meat.

The first problem to arise was whether to grind the meat at the Barnstable factory or request the dealer to grind it. As the dealer did not possess a meat grinder, a few chunks of horse meat were shipped to Barnstable from Boston for grinding. It was found that the Enterprise grinder at the factory was too slow to grind the meat either cold or cooked due to gristle present in the meat. The producer of the horse meat agreed to install a fast electric grinder to do the work.

The second problem was the matter of transportation of the meat from Boston to Barnstable to prevent spoilage during hot weather as daily shipments during cool weather did not have any

Table XXIII. Typical Batch in Canning Fish Bait

1. Place 300 pounds of frozen fish in baskets of steam retort.
2. Process for 17 minutes at five pounds pressure. (226.9°F)
3. Remove dehydrated fish from retorts to platform scales.
4. Run through grinder 224 pounds of dehydrated fish.
5. Place ground fish into mixing machine.
6. Add 16 pounds of powdered red squill to fish in mixer.
7. Add 20 pounds of water to fish and squill in mixer.
8. Run mixer for 15 minutes.
9. Remove mix into tubs, placing tubs on filling table.
10. Fill cans by hand with use of ice cream scoops.
11. Place about 400 filled cans in small retort.
12. Exhaust cans for 10 minutes at five pounds pressure.
13. Test temperature of can contents which should be at least 160° F.
14. Run cans through sealing machine to put on covers.
15. Pack sealed cans in processing retort until retort is filled.
16. Process cans for one hour at 15 pounds pressure. (249.1°F)
17. Cool cans immediately by running in cold water.
18. Drain and remove cooled cans from retort.
19. Pack cans into cases for storage.

marked effect upon the condition of the meat. This problem was solved by adding one percent sodium sulphite just after the meat had passed through the grinder. It should be noted that the addition of sodium sulphite does not effect the acceptability of the bait to rats as seen in Table XVI. This chemical is added to commercial hamburg at the rate of one-half of one percent and is not detected by humans.

The third problem encountered was that the meat expanded over the tops of the cans during the exhaust process leaving free water that spilled over during removal from the retort and during the sealing process. This difficulty was remedied by placing sheets of galvanized iron between the rows of cans in the retort thus preventing this upward expansion.

The fourth problem was the best method to apply dry powdered red squill to the meat and flour mixture. As there is no free water in meat or flour, the particles of squill tended to adhere to the wet meat in clumps thus preventing a complete distribution throughout the bait. To overcome this difficulty, the powdered squill was made into a very wet paste by adding the water necessary for the batch formula.

7. The Final Process and Formula Used in Canning Meat Bait.

The final process and formula gave a fairly uniform bait when opened. The free water in the exhaust process was absorbed into the meat again during the final process. Data on a typical batch of meat is given in Table XXIV.

Table XXIV. Typical Batch in Canning Meat Bait

1. Place 200 pounds of meat in mixing machine.
2. Mix into a smooth paste 16 pounds of powdered red squill by adding 52 pounds of water slowly.
3. Add squill paste to meat in mixer.
4. While mixer is going, add 24 pounds of flour. Run 15 minutes.
5. Remove mix in tubs, placing tubs on filling table.
6. Fill cans by hand with use of ice cream scoops.
7. Place about 400 filled cans in small retort.
8. Exhaust cans for 15 minutes at five pounds pressure.(226.9°F)
9. Test temperature of can contents which would be at least 160° F.
10. Run cans through sealing machine to put on covers.
11. Pack sealed cans in processing retort until retort is filled.
12. Process cans for one hour at 15 pounds pressure. (249.1°F)
13. Cool cans immediately by running in cold water.
14. Drain and remove cooled cans from retort.
15. Pack cans into cases for storage.

8. Problems in Canning Oats Bait.

Most of the difficulties in canning a grain bait appeared in the preliminary laboratory work. As there was no outstanding choice of grains by rats as seen in Tables VIII, IX, and X, the simplest grain to use would have been rolled oats. The resulting canned bait of rolled oats and water required a very exact formula and process to give a final bait neither too wet nor too dry. On a commercial scale it would have been impossible to obtain uniform batches with such an exact formula and in addition the consistency was thought to be unattractive to rats. The best formula found consisted of equal parts of rolled oats and soaked wheat plus water. It was not possible to add sufficient water in the can using dry rolled oats and whole wheat. By soaking the wheat in an equal quantity of water overnight, it is learned that this is about the mixiмum absorption of water except when cooked. By combining the wheat with the oats, the oats particles were separated by the wheat particles and gave a bait of good consistency.

The proper exhaust for oats bait required some experimental work. In Table XIX it is seen that the usual exhaust time and pressure that will be withstood by fish or meat raised havoc with the oats bait. As the oats bait is much more watery than the fish or meat bait, heat penetration is much quicker so that the desired exhaust temperature is quickly reached. Thus, an exhaust of about ten minutes using no pressure was the satisfactory exhaust process.

9. The Final Process and Formula Used in Canning Oats Bait.

A few experiments were required to determine the exact amount of water to add to a large batch to give the proper consistency to the bait. Although it would probably be possible to add the powdered red squill directly into the wet mix of rolled oats, soaked wheat and water, it was thought best to make a paste of the squill before adding it. Data on the final process and formula is given in Table XXV.

J. Field Results with Canned Rat Bait.

1. Method of Measuring Results.

It is not possible to obtain an accurate picture of results by exposing any rat baits over a few or even fifty places of infestation. There are many variable factors, all of which are not fully understood. It is easily understood that the normal food supply of rats in the field varies from farm to farm or place to place so that the acceptance of new food might vary depending upon their previous normal food supply. Even on farms where the main source of food of rats is grain, there seems to be a wide variation in the acceptance of the same exposed baits from farm to farm. Due to lack of personnel and time to make scientific tests with trained workers, it was necessary to resort to the mail return report card.

After a county-wide rat campaign was concluded, questionnaires were mailed to all cooperators. At this point it might be mentioned that each cooperator exposed the rat bait himself so there would be a variation in this regard in that instructions may not have been followed. The average return of these report cards has been around 25 percent. It is assumed that the balance of 75

Table XXV. Typical Batch in Canning Oats Bait

1. Soak overnight 40 pounds of whole wheat in 40 pounds of water.
2. Place 80 pounds of rolled oats in mixer.
3. Add the 80 pounds of soaked wheat and water to oats in mixer.
4. Mix 16 pounds of powdered red squill in 64 pounds of water.
5. Add squill-water mixture to oats and wheat in mixer.
6. Run mixer for five minutes.
7. Remove mix into tubs, placing tubs on filling table.
8. Fill cans by hand with use of ladles.
9. Place about 400 filled cans in retort.
10. Exhaust cans for 10 minutes using no pressure.
11. Test temperature of can contents which should be at least 160° F.
12. Run cans through sealing machine to put on covers.
13. Pack sealed cans in processing retort until retort is filled.
14. Process cans for one hour at 15 pounds pressure. (249.1°F)
15. Cool cans immediately by running in cold water.
16. Drain and remove cooled cans from retort.
17. Pack cans into cases for storage.

percent were as fully satisfied and obtained at least as good results as the 25 percent who returned the report cards. By compiling this information from many campaigns, it is thought that errors and incorrect observations and other variations should be equalized. It will be noted that there is a large variation in reported results from one campaign to another but it is probably due to the small number of cards returned. Table XXVI is a typical analysis of several campaigns.

2. Comparing Fresh Bait with Canned Bait.

The determination of the value of canned red squill rat bait was made by the comparative method. As there is no fixed standard for any rat bait, all conclusions are comparative. Before the advent of canned bait, a large number of rural rat campaigns had been conducted with fresh bait. As an analysis of the results of fresh baits had been kept, it was possible to continue the same type of analysis and compare them. (Table XXVII.)

Discussion of Results

The most important figures in this table are the ones concerning "percent no live rats left." With fresh bait the report cards show that 59.5 percent of the persons reporting obtained 100 percent clean-up of all rats on their premises. Using canned bait, 49.3 percent obtained a similiar clean-up. It is clear that canned bait is not quite as effective as fresh bait but nearly so. The figures are consistent as 81.9 percent of those using fresh bait were satisfied and 75.2 percent of those using canned bait were sat-

Table XXVI. Typical Analysis of Field Results with Rat Bait

Place	Cards Sent	Cards Back	%	% No Rats	% Satisfied
Sullivan Cty., N. H.	416	153	37.0	30.0	78.0
Barnstable Cty., Mass.	325	87	26.8	56.5	86.6
Litchfield Cty., N. H.	25	11	44.0	44.4	75.0
Middlesex Cty., Mass.		23		57.0	70.0
New Haven Cty., Conn.	772	141	18.3	72.0	72.0
Worcester,Cty., Mass.	2500	262	10.5	86.3	90.4
Essex Cty., Mass.	831	206	25.0	47.0	80.0
Bristol Cty., Mass.	300	120	40.0	62.6	97.8
Norfolk Cty., part Mass.	180	55	30.5	47.8	84.9
Windham Cty., Conn.	430	72	16.7	49.0	76.0
New London Cty., Conn.	622	154	25.0	72.0	85.0
Cheshire Cty., N. H.	649	154	23.6	39.3	78.0
Windham Cty., Vt.	335	91	27.0	25.9	74.1
Hampden Cty., Conn.	480	55	11.4	54.0	78.0
Totals	7865	1584	25.8	53.1	80.4

	Found Dead Rats	Odor	Reporting Damage	Average
Sullivan Cty., N. H.	36.6 %	18.3 %	41.0 %	$39.11
Barnstable Cty., Mass.	42.5	18.5	34.4	52.83
Litchfield Cty, N. H.	63.6	20.0	50.0	54.00
Middlesex Cty., Mass.	57.0		30.0	34.64
New Haven Cty., Conn.	36.0		22.0	40.20
Worcester Cty., Mass.	33.6	19.1	28.7	26.76
Essex Cty., Mass.	50.0	10.0	34.0	40.34
Bristol Cty., Mass.		7.5	68.3	16.51
Norfolk Cty., Mass.	58.2	3.8	49.1	95.26
Windham Cty., Conn.	53.0	10.0	27.0	40.35
New London, Conn.	37.0	5.5	51.0	45.85
Cheshire Cty., N. H.	40.0	25.2	40.0	24.00
Windham Cty., Vt.	32.0	18.6	17.6	25.00
Hampden Cty., Mass.	38.0	4.0	35.0	31.16
Average Fall	44.4 %	13.4 %	37.7 %	$39.71

Bait Acceptance

Place	Cards	Hamburg	Fish	Grain
3 towns, Rochingham, N.H.	79	44	31	6
Madison, Conn.	24	3	3	3
Rockingham Cty., N. H.	160	107	3	3
Strafford Cty., N. H.	20	11	2	4
Middlesex Cty., Mass.	269	142	100	100
Belknap Cty., N. H.	63	18	6	13
3 towns, York, Maine	28	9	2	4
Standish, Maine	10	7	2	2
Total Spring	653	341	221	207

Table XXVII. Summary of Analyses of Report Cards

Comparing Fresh Bait and Canned Bait

Bait 1 Fresh meat, canned fish, fresh moist grain - powdered squill.

Bait 2 Canned meat, canned fish, canned moist grain - powdered squill.

		Number 1		Number 2	
Percent return of cards		29.2		22.5	
Number of cards analyzed		4,565		7,959	
Percent satisfied with bait		81.9		75.2	
Percent no live rats left		59.5		49.3	
Percent finding dead rats		37.1		39.0	
Average yearly damage by rats (those reporting)		$30.60		$34.85	
Bait acceptance	meat	1,080	40.0%	1,699	24.9%
	fish	721	26.6%	1,516	20.0%
Number stating best bait taken	grain	687	25.0%	1,156	15.2%
	no choice	161	5.9%	2,408	31.5%
	none eaten	52	2.9%	844	11.1%
	all	21	0.8%		

isfied but the persons using canned bait were not quite as well pleased as the results were somewhat poorer. Also the percentage of uneaten baits ran higher with canned bait than with fresh bait as would be expected.

It was observed that the relative acceptability of the baits in the case of baits agreed with the acceptability of fresh baits and all canned baits were slightly less palatable than fresh baits. It may be seen that fresh hamburg was the leading bait but when canned the relative acceptance to other baits was lowered considerably so that all canned baits were more or less equally palatable. This observation would account for the larger number of "no choice" places with canned bait over fresh bait.

The final conclusion of the field tests might be that the convenience of canned bait very nearly offset the slightly lower results with this type of bait.

SUMMARY

1. The literature on red squill as a raticide, rat bait formulas containing red squill, and canning technique was reviewed.
2. Oven-dried powdered red squill was the most reliable type of red squill to use in the experiments to develop a canned rat bait.
3. Meat, grain, and fish baits were the three most promising types to use for canning.
4. Moist baits with squill were more palatable to rats than dry baits.
5. Various oils did not increase the acceptability of squill baits.
6. Hamburg or horse meat were the best kinds of meats.
7. Whole wheat and rolled oats were the most palatable grains to rats.
8. Canned fresh fish or canned fish meal and rolled oats were the best fish baits.
9. Lures or essential oils did not increase the acceptability of baits.
10. The presence of squill in baits slows up acceptance, but in a toxic concentration, sufficient poison bait is consumed to kill rats.
11. The canning process does not destroy the toxicity of red squill.
12. It is possible to can meat, fish, and grain baits commercially.
13. Canned rat baits are slightly less effective than fresh baits but their convenience gives them an advantage.

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